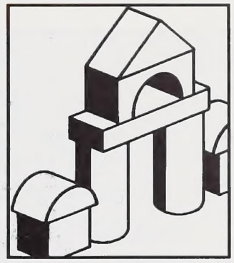
Heritage Notes

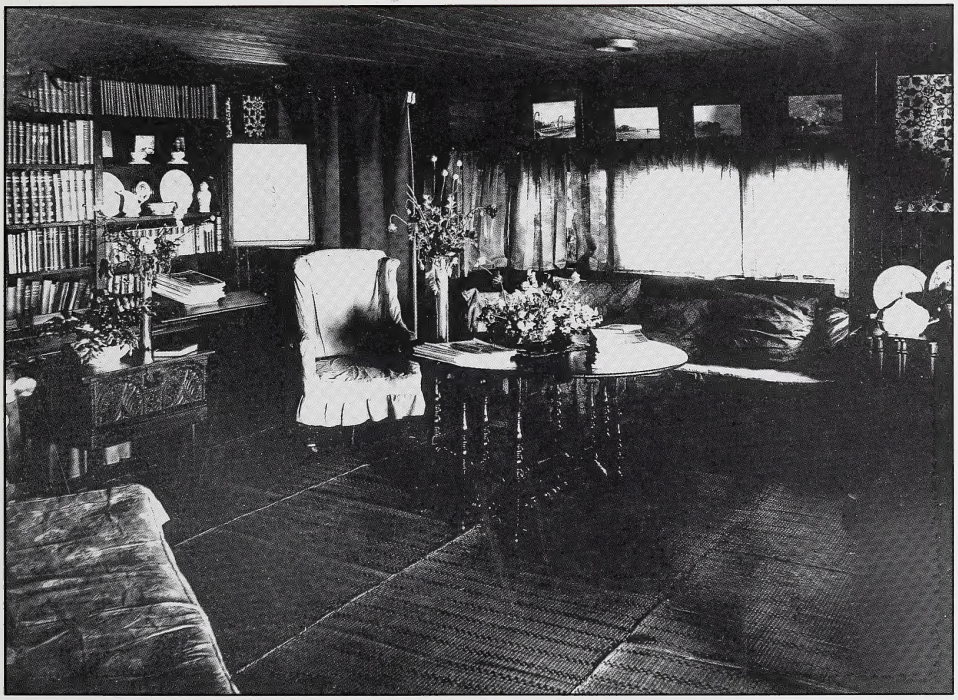
Architectural Preservation



Number 8

Structural and Subfloor Repairs

David Koshman



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The floors in just about every older house have problems of one sort or another. More often than not, these minor annoyances are nothing more than that, and are part of an older building's character. In some instances, however, problems created by moisture, settling, or insect and fungal attack require further attention. This *Heritage Note* will examine the elements that make up the subfloor's structural system, identify the problems one might expect to encounter, and offer possible solutions for some of the problems a homeowner may encounter with his or her floors.

When confronted with squeaking, sagging, sloping or bouncy floors, many homeowners look no further than the floor's outer layer, which is known as "the finish floor". But in most cases, problems in the finish floor are outward signs of deeper troubles, either in the sub-floor or the structural members beneath it. Dealing with the finish floor alone is usually a waste of time and money. The systems beneath the floor must be inspected and the true cause of the problem identified before the situation can be corrected. Only then should the finish floor be repaired.

The good news is that the structural system under a floor is fairly easy to understand, and although the probing and inspection can be a messy job, the problems, once identified, can be managed by many homeowners. (See Figure 1. "Subfloor structural system.")

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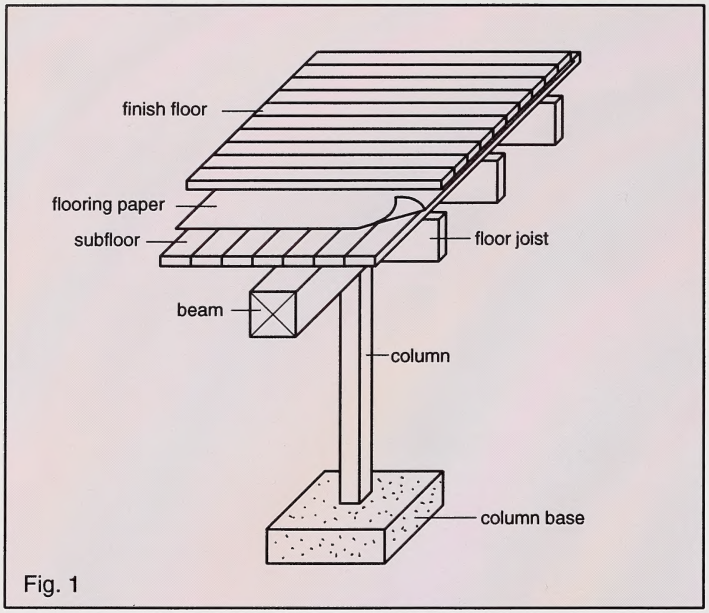


Fig. 1

Figure 1. Subfloor structural system. This illustration identifies the components of the subfloor structural system and shows their relationship to each other.

Flooring Paper

Flooring paper should always be added between the subfloor and finish floor when the floor is installed, to cushion the rubbing action of wood on wood. If paper is missing, this may explain why your floors squeak despite all your efforts to rectify the problem. Isolating these two elements at the time of construction can help eliminate one potential source of squeaking.

Solution: When installing new or replacement flooring, always ensure that a flooring paper is installed. Re-laying a finish floor just to put in a layer of paper is not recommended. Check under the heat registers to see if paper was installed between the finish floor and subfloor during construction. If not, and you have determined that there are no structural problems, you'll just have to live with the noise until you re-do the finish floor.

Subfloor

Over the years the subfloor can become loose, resulting in a squeaky, noisy floor. This can have several causes. Perhaps the fasteners used to secure the subfloor to the joists were too small or too few and have worked loose after years of pedestrian traffic. Another reason for a squeaky subfloor is shrinkage as the wooden members dry out over time. In this case, the fasteners may still be in place, but with the reduced thickness of the wood, the subfloor can move up and down on the fasteners, resulting in a squeaking noise. Other dimensional changes in the subfloor material, such as reduced width or cupping, can also loosen the subfloor with the familiar result.

In other cases, the squeaking may come from the subfloor but the problem rests in your floor joists. When your floors are springy or bouncy, the floor joists may be undersized, improperly spaced, or inadequately supported. The up-and-down movement of the floor as one walks across it causes the subfloor members to rub against each other, so even though they are firmly attached to the joist, they still squeak.

Solution: When the subfloor has become loose, for whatever reason, the important thing is to stop the movement which causes the squeaking noise. Have someone walk on that part of the floor while you direct their movements from below. If the offending boards can be narrowed down to just a few, then often simply driving a thin wedge between the subfloor and the joist will stop any movement. Cedar shingles make ideal wedges. To prevent them from working their way out, "butter" both sides of the shingle with glue before driving it in.

However, if the finish floor above has crowned slightly because of the loose subfloor, driving a wedge in will make this crown a permanent feature. Providing that the subfloor is firm and secure on either side of the boards that are making the noise, a better solution is to screw a six-inch wide strip of 3/4" plywood to the underside of the subfloor. Make sure the plywood is long enough to span two or three subfloor pieces on either side of the offending

boards. This method will draw the loose subfloor down and keep it quiet (see Figure 2).

If the squeaking seems to be coming from every place the person above walks, then a slightly more involved solution may be needed. First, determine if indeed there is a separation between the joist and subfloor. This can be done by using a section of 2" x 4" to push up the underside of the subfloor. If there is no separation, you must look elsewhere for the cause of the squeak. But if there is enough separation to allow even a small movement, this can cause squeaking. Try the following procedure to draw the subfloor down snug and prevent it from moving.

Cut strips of 1/2" plywood the depth of the floor joist and 8' long. Screw a piece of 2" x 2" to the upper face of the plywood and then attach the plywood to the floor joist, keeping the plywood and 2" x 2" flush with the upper edge of the floor joist.

Once the plywood is securely fastened to the joist, then drive screws up through the 2" x 2" and into the subfloor to draw it down tight. Use two screws on every piece of subfloor and be sure they are long enough to grip the subfloor firmly, but not long enough to pierce the finish floor (see Figure 3).

The Floor Joists

The floor joists are the structural members that span the foundation, and upon which the subfloor is nailed. Floor joists can be 2" x 6", 2" x 8", or 2" x 10" material, and are generally spaced 16 to 24 inches apart. The size of the floor joists depends on the distance they are spanning, as well as the distance between joists. The Alberta Building Code outlines what is acceptable in any given situation.

Usually, problems with floor joists arise when they are either deficient or defective. "Deficient" means that they are undersized or there are too few of them for the job they were intended to do. The result is a floor that is bouncy when walked upon, sags in the centre, squeaks, or all of the above. "Defective" means the floor joists have been milled from poor

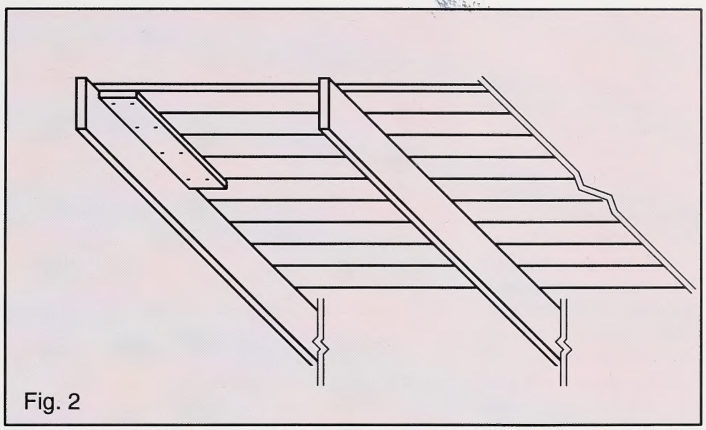


Fig. 2

Figure 2. If one or two subfloor boards are loose, a 6" wide strip of 3/4" plywood, spanning the loose boards and two or three sound boards on either side, can be used to draw down the loose subfloor boards using screws.

quality material with large knots, cracks and checks. They may also be defective because of attack by insects, fungus or man. Insects and fungus can attack wood when the moisture content in the wood is high because of periodic basement flooding or high humidity. Man-made damage, the most common cause of defective floor joists, is usually caused by poor installation techniques. Often, tradespeople cut

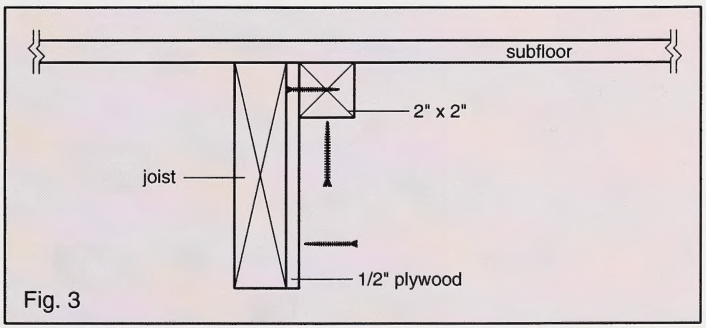


Fig. 3

Figure 3. Areas of loose subfloor can be secured by using 1/2" plywood with 2" x 2" strips attached. Then, attach the plywood to the existing floor joist and drive screws up through the 2" x 2" as shown to draw the subfloor down snugly.

holes through the joists when installing wiring, plumbing, or heating ducts, reducing the strength and carrying capacity of the member. For example, if you have a 2" x 8" floor joist and a 3" deep notch is made in the joist during installation of your heating system, then the strength of that joist is reduced to that of a 2" x 5" joist (see Figure 4). Correcting these defective joists is more difficult because of the very systems that caused the defect.

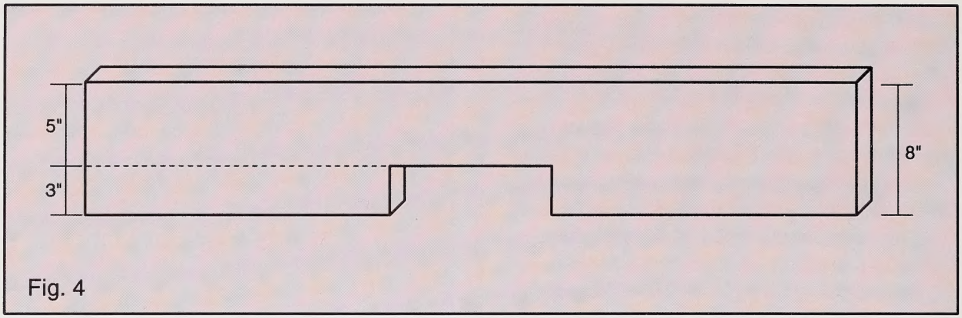


Figure 4. By making a three inch deep notch in a 2" x 8" joist, you reduce its load-bearing capacity to that of a 2" x 5" joist.

Solution: In the case of deficient floor joists, several things can be done. Where the floor joists are undersized, a second floor joist can be nailed to the original to increase its strength. Where there are too few, a new floor joist can be installed between each pair of existing floor joists. In order to install the new floor joists, the sagging floor and floor joists would have to be jacked level.

Often these measures are not practical when wiring, ducts or plumbing would interfere with the placement of new joists. An alternate solution is to halve the span of the existing joists by adding a perpendicular built-up beam supported on columns, as shown in Figure 5. This can only be done when the existing basement floor provides adequate support for the new columns. Otherwise, column bases will have to be installed. Yet another approach is to install a load-bearing or partition wall. None of these solutions may be ideal for those wishing to keep the space below open. In that case, you may have to wait until the old wiring, heating, or plumbing system is removed and double the joists before the new systems are installed.

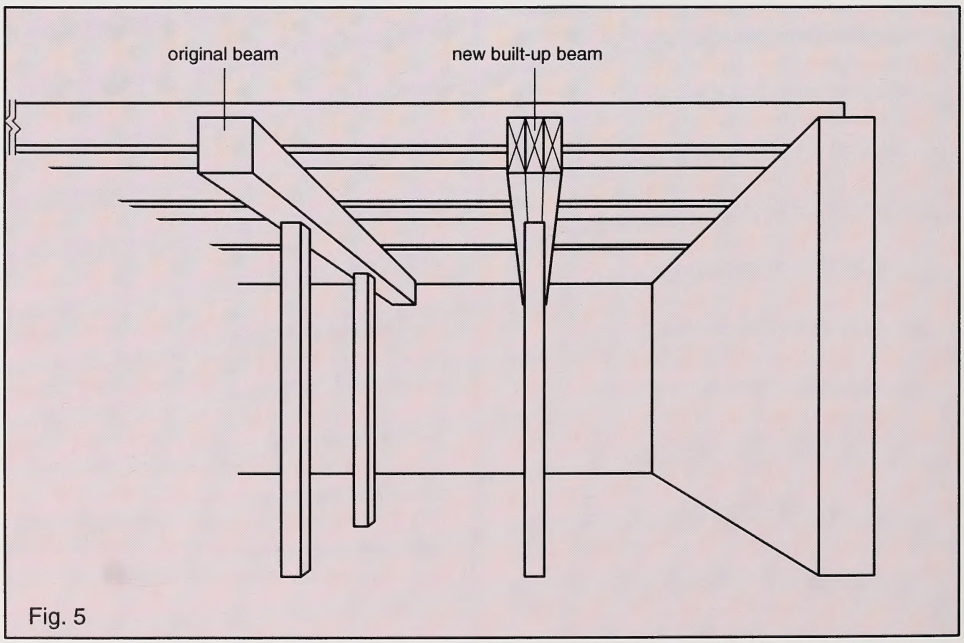


Figure 5. When your floor sags or bounces, you can reduce the joist span by adding a new built-up beam at the mid span of the joists. Alternatively, you can install a load-bearing partition wall. Whichever method you choose, adequate bearing must be provided under the basement floor.

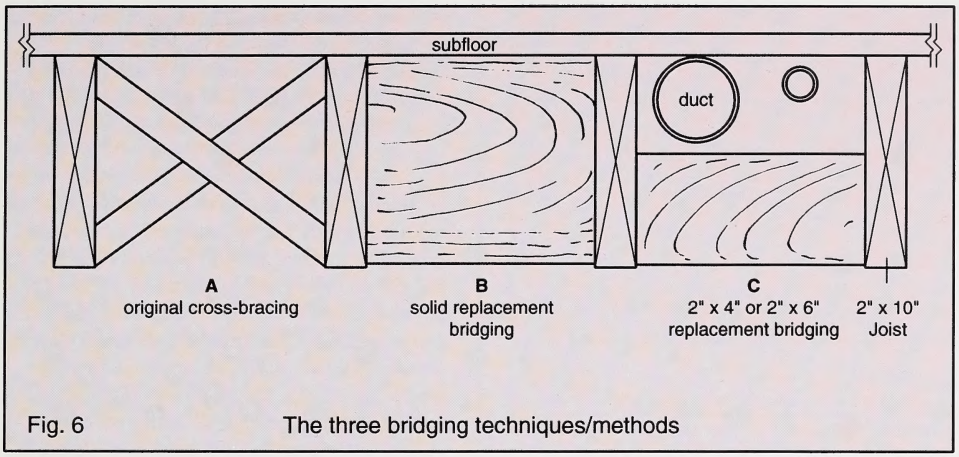


Fig. 6 The three bridging techniques/methods

Figure 6. Three bridging methods: A. original cross-bracing (best) B. solid replacement bridging (good) C. 2" x 4" or 2" x 6" replacement bridging (better than nothing). Cross-bracing is very difficult to install once the subfloor is in place. If you have to remove cross-bracing in order to carry out repairs to the subfloor, then the bridging methods illustrated in B and C should be used to serve the same purpose.

Bridging Between the Joists

Bridging is an important element in the subfloor structure as it transfers loading from the joist being walked upon to the adjacent joists, a concept referred to as "load sharing." Bridging between floor joists that has been removed over the years should be replaced. The cross-bracing method of bridging, shown in Figure 6 A, which is found in most older homes, is too difficult to re-install. Instead, solid bridging should be used. Solid bridging consists of material the same thickness and depth (usually 2" x 8" or 2" x 10") placed snugly between the joists, as shown in Figure 6 B. If later additions make the installation of solid bridging impossible, half bridging should be used, as shown in Figure 6 C.

Beams

Beams are the structural members that run perpendicular to the floor joists, helping them carry their load by reducing the distance spanned. Beams are usually supported by pockets in the foundation wall and by columns placed strategically along their length at distances prescribed by the building code.

In older homes the beams were often one solid piece of lumber, usually a 6" x 6" or 8" x 8". Today most beams are either "built-up beams" made by nailing together a minimum of three pieces of 2"x 8" or 2" x 10", or are a single piece of steel I-beam.

The problems related to beam failure are much the same as those discussed in joist failure. When beams are undersized for the loads they are to carry, they flex when loaded. If the loading above is too severe the beams can fracture. Often the beam is adequately sized, but the columns are spaced too far apart. And finally, the beam may be the right size and there may be adequate columns, but close inspection reveals that the columns are not properly supporting the beams. All these situations can result in bouncy, squeaky floors.

Solution: If the beam is undersized, there are several approaches that can be taken. The floor joists can be temporarily supported on either side of the existing beam until it can be removed and a properly sized beam installed. Alternatively, additional beams and posts can be installed between the original beam and the foundation wall to reduce the joist span and hence the load on the original member, as shown in Figure 5. A third approach would be to simply increase the number of columns supporting the beam.

If the columns are not properly supporting the beam, it will sag. For this reason, it is important to ensure that the beam is level. If the columns have settled the beam will sag and the joists above will follow, resulting in a sagging floor above.

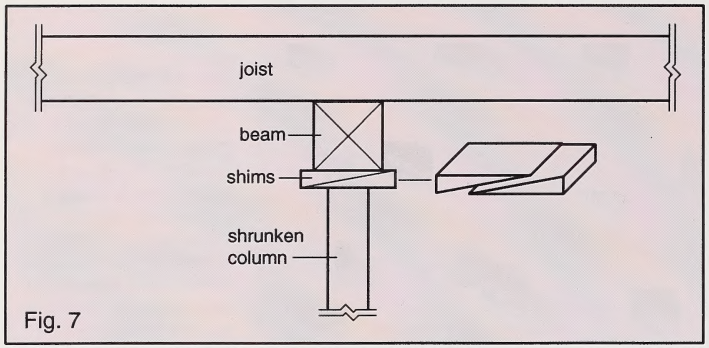


Figure 7. Wooden columns that have shrunk can be "snugged" up again by driving in wedges between the top of the column and the underside of the beam. These wedges, or shims, can be adjusted to accommodate minor changes resulting from alternating damp and dry conditions.

Columns

Columns (or posts) are the upright members that transfer the load from the beam to the foundation below the basement floor. As with other elements, failure of the columns can be caused when they are deficient, that is, too small for the load, or there are not enough columns for a given span. When a column is undersized it can bend under the load placed upon it, causing the structural system it supports to bounce and squeak.

A common cause of column failure is the action of moisture or insects, which can weaken columns which were originally able to support their load.

Wooden columns, if put in green, can shrink and become too short to support the beam above at its original height. Wooden columns are of a fixed length and cannot be adjusted to accommodate this shrinkage. Conversely, in basements with serious moisture problems, the wooden columns can swell and cause the floor above to crown.

Solution: Most columns today are made of steel and are rated according to the load they can carry. If old wooden columns need replacing, steel ones are often used. The building code tells us the number of columns required under a given span and the load carrying capabilities these columns should have. (See Canada Mortgage and Housing, *Canadian Wood-frame House Construction,* 1981.) If you wish to replace the columns with wooden ones, or if you want to know if the existing columns are adequate, there are formulae for determining the allowable slenderness ratio in a column. These take into consideration the height of the column, the wood species, the live and dead loads being applied, etc.

Wooden columns that have shrunk can be replaced or they can be "snugged" up again by driving in wedges between the top of the column and the underside of the beam. Ideally, the wedges should be the width of the beam and should be driven in from opposing sides, as shown in Figure 7. This approach allows for future adjustment, should conditions change. Indeed, if deteriorated or defective wooden posts are being replaced in kind, they should be sized to accommodate wedges. If you are in doubt, consult a professional builder, architect or structural engineer.

Column Footings

All too often, what is perceived to be column shrinkage resulting in a sagging floor system is really inadequate column bases that have sunk under the load. In older homes, it is not uncommon to find columns resting on flat stones, bare earth, or another piece of wood. In some instances, the basement was poured around the column base and what it is resting on is unknown, or the column is just sitting on the basement floor with no other support system in place. A concrete floor is not designed to carry the type of point loading a column exerts and is bound to crack and deflect over time.

Solution: All columns must be properly supported on column footings specifically designed to carry the imposed load. When building a new house, the column bases are poured at the same time as the footings. Then the basement floor is poured up to or over top of them. In existing buildings with a concrete basement floor, an area the size of the proposed column base must be cut out of the basement floor and any loose material removed, down to stable soil. For most residential dwellings the footing illustrated in Figure 8 will be adequate.

Insect and Fungal Attack

Insect and fungal attack can occur in each and every element of the subfloor structural system, with disastrous consequences. Either can go undetected for years and the result can be severe weakening and even failure of the subfloor elements.

In Alberta we do not have to worry about termites, but we do have several insects that are of concern, including the carpenter ant, the wood wasp, and the powder post beetle.

The phrase "fungal attack" covers a broad range of fungi which inhabit wood and live by digesting either the cellulose or lignin components of the wood. Fungal attack by most of the many species of fungi can be directly attributed to the presence of water, either in liquid form or from high humidity levels.

Solution: Insect infestation, if relatively small and detected early, can be handled by the homeowner using over-the-counter products. It is essential to follow the manufacturer's instructions for application, as well as all safety guidelines. In the case of a large well-established insect colony, a professional exterminator should be hired.

Where subfloor elements are being weakened by fungal attack, it is crucial that the source of the moisture be identified and eradicated. Some common causes are leaking plumbing, broken or detached downspouts for eavestroughs, poor drainage around building, lack of adequate ventilation (particularly in crawlspaces), periodic flooding from heavy rains, or spring runoff.

Only after the moisture problem has been corrected can the affected subfloor element be repaired. It is probably worth mentioning here that decay fungi can lay dormant for years, so even if the source of moisture is removed, they can resume their attack as soon as moisture is reintroduced. For this reason, it is often best to remove the area of deteriorated wood and a foot of sound wood on either side of the decay.

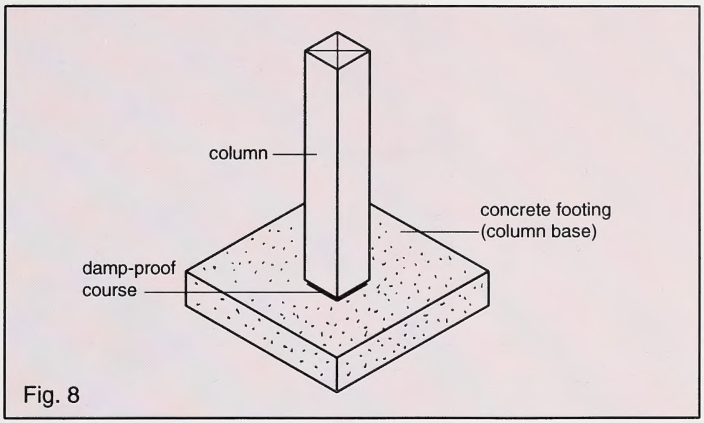


Fig. 8

Figure 8. All columns must be properly supported on footings specifically designed to carry the imposed load. On stable soil, the footing should be 2' by 2' for a single storey and 3' x 3' for a two storey house. The minimum thickness should be 6".

If this is not possible or practical, then the affected areas of wood should be treated with a fungicide before new wood is placed near it. Exercise caution in the choice of fungicide and its application, and consider how this area is used by humans or animals.

Because it is hard to determine the strength remaining in a structural member that has suffered from insect or fungal infestation, it is best to replace it.

Finish Flooring

If your floor still squeaks after you have seen that all subfloor structural systems are intact and functioning properly, the problem must lie with the finish floor. In Alberta, the majority of flooring in older houses is "tongue and groove," a method of joining illustrated in Figure 9.

Solution: Inspect the finish floor closely. A previous owner of the house may have tried to "fix" the floor by nailing loose boards down, and these nails may have popped. In most cases, they should be removed and the holes filled with a plastic wood or putty to match the floor. However, when removing the nail would cause more damage to the floor, as when flooring nails rather than common nails have been used, it should be countersunk and filled.

Next, check for loose boards, which may be rubbing against each other to cause the squeak. From an aesthetic point of view, it is best to

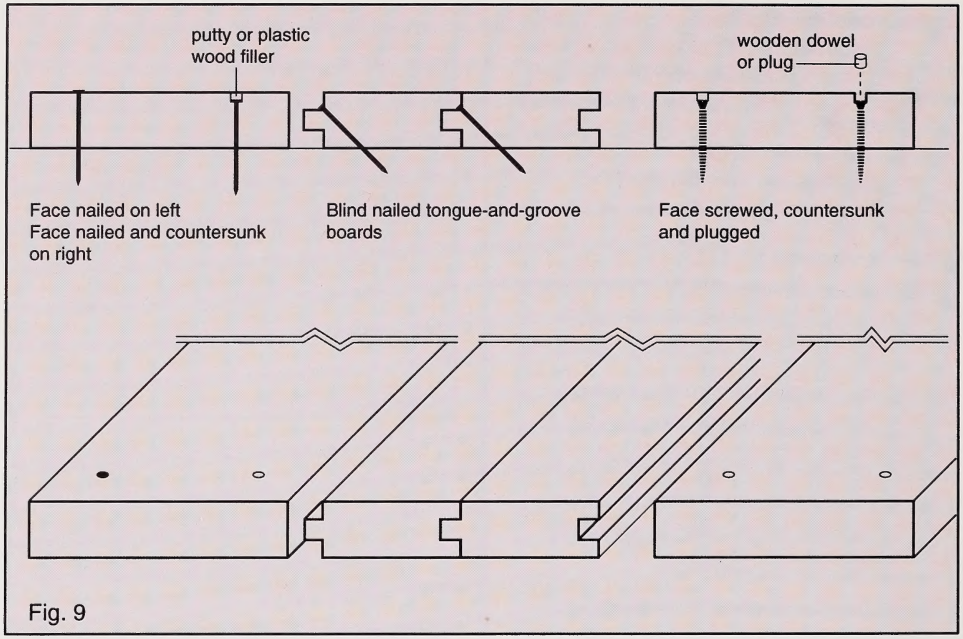


Figure 9. Common floor nailing methods.

fasten the floorboards to the subfloor from below. Drive screws of an appropriate length up through the subfloor into the finish floor to draw it down tightly. Of course this method is only preferable when the room below is unfinished.

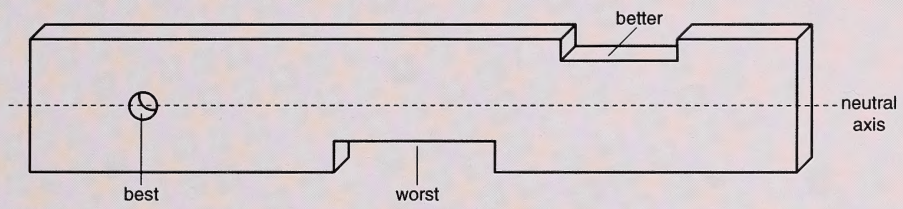
If this is not the case, the problem floor must be dealt with from above. Tongue and groove floorboards are "blindnailed" to the subfloor, as shown in Figure 9. This means that the nails are not visible. Using a magnetic studfinder to locate the original nails, pre-drill and nail next to them. Often it is the movement of the board on the original nails that causes the squeak, so nailing further along the board will do no good. It is best to use flooring nails for this job, which are spiral nails with good holding power. Where possible, nail over a joist for added strength. Finally, countersink the new nails and fill the holes to match the floor. At this point, the floor may need to be refinished, but that is beyond the scope of this Note.

Conclusion

If the floors in your older home have more problems than you are willing to live with, then you must take a holistic approach to solving them. First of all, do not look for all the answers in the most obvious place, the finish floor. You must systematically eliminate or confirm other causes or contributors to the problems you are experiencing. Start with the simplest solutions, such as wedges between subfloor and joist, and if necessary, work your way up to the more difficult and costly solutions, such as jack hammering out the basement floor to install new column bases.

As stated at the beginning of this *Heritage Note*, the structural system under the floor is fairly easy to understand. Once you have found the source of the trouble and discover that it is not serious, you may be satisfied to leave it be. On the other hand, if you uncover an unsafe situation, you may be able to carry out the work yourself, or feel confident in directing others.

A great deal of satisfaction can be gained by acquiring an understanding of your house's basic structure. This understanding, combined with your new found analytical skills, will give you the confidence to meet the many challenges of an older home.



Joist or beam

The Recommended Places to Cut Joists

If a beam or joist must be notched to allow wiring or ducting to be installed, the preferred location is in the middle of the joint, that is, the neutral axis. However, the diameter of the hole should not exceed 1/4 of the depth of the beam or joist. The underside of the member is the worst place to notch, from a structural point of view. The top of the member is not as bad but is not very accessible.

For more detailed information on notching and drilling, refer to subsection 9.23.5 of the Alberta Building code.

Summary Chart of Flooring Problems, Possible Causes and Suggested Solutions		
Problem	**Possible Cause**	**Solution**
Floor Bounces	Floor joists too small	Double joist
	Floor joists too far apart	Intermediate joist
	Floor joists spanning too far	Add beam to halve span
	Bridging between joists missing	Install bridging
Floor sags	Column shrinkage	Wedges between column and beam
	Column base settled	Re-level floor and pour column base
Floor squeaks	Loose finish floor	Secure finish floor to subfloor
	Loose subfloor	Shim between subfloor and joist
		Draw subfloor down with wood and screws
	No bridging or loose bridging	Install bridging or add fasteners to stiffen the existing bridging
	Deficient joists	Double joist
		Add beam to halve span
Insect attack	High moisture content in wood	Eliminate source of moisture
	Insect food source nearby	Eliminate food source and exterminate insects
Musty odor	Decay fungus	Eliminate source of moisture
		Check structural soundness

Keys to Further Information

Canada Mortgage and Housing. *Canadian Wood-frame House Construction.* 1981.

City of Oakland Planning Department. *Rehab Right.* Oakland: City of Oakland,1978.

Evers, Christopher. *The Old-House Doctor.* Woodstock, New York: Overlook Press, 1986.

"How to Stiffen Sagging Floors." *The Old House Journal*, February 1974, p. 1, 9-11.

"How to Deal with Sagging, Sloping, Squeaking Floors." *The Old House Journal*, January 1981, p. 7-10.

Hutchins, Nigel. *Restoring Old Houses.* Toronto: Van Nostrand Reinhold, 1980.

Kline, Donna. "Installing New Joists and Beams." *The Old House Journal*, June 1976, p. 3-6.

Landry, Arthur W. *Restoring Old Houses.* New York: Sterling Publishing, 1982.

Litchfield, Michael. *Renovation, A Complete Guide.* New York: John Wiley and Sons, 1982.

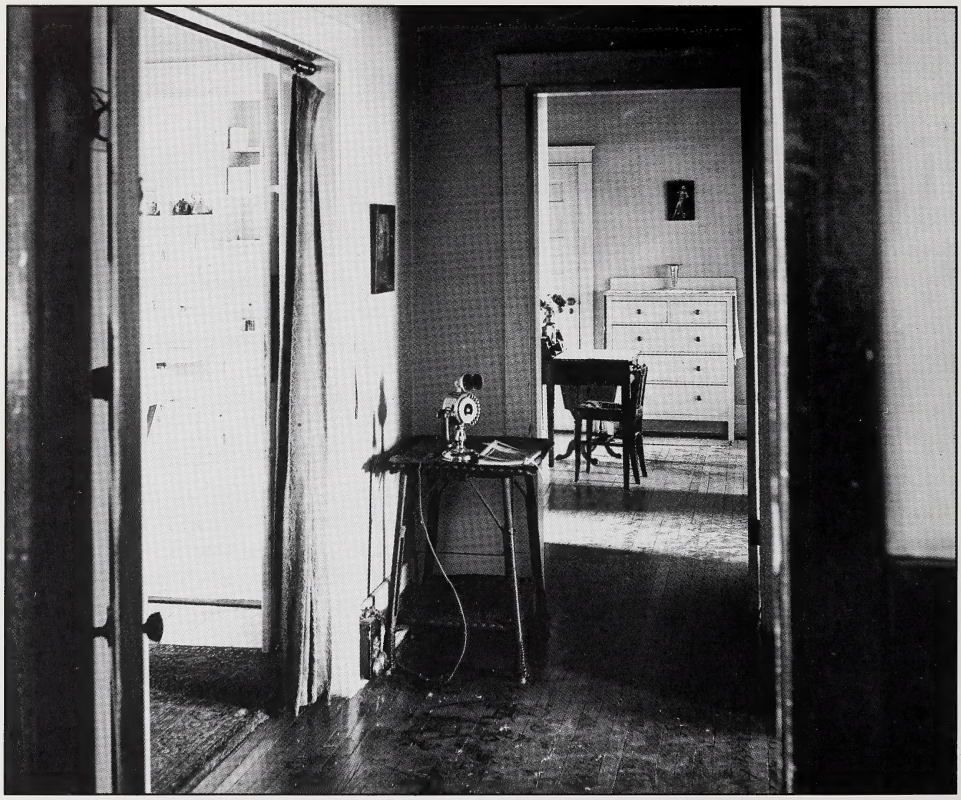
Melville, Ian A. (FRICS), and Ian A. Gordon (FRICS). *The Repair and Maintenance of Houses.* London, England: The Estates Gazette, 1973, reprinted 1979.

Paulsen, Gary. *The Building a New, Buying an Old, Remodelling a Used Comprehensive Home and Shelter How-to-do-it Book.* Englewood Cliffs, NJ: Prentice-Hall, 1976.

Poore, Patricia. "Fixing Old Floors: Construction Types and Subfloor Repairs." *The Old House Journal*, February 1981, p. 48-50.

"Repairing Old Floors." *The Old House Journal*, May 1974, p. 1, 9-11.

Russell, Karen. *Guidelines for the Rehabilitation of Designated Historic Resources*, 2nd ed. Edmonton: Alberta Community Development (formerly Alberta Culture and Multiculturalism), 1993.



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Heritage Notes are intended to provide guidance to the people of Alberta on a range of topics in the field of historic resource management. Readers' comments on the series are welcome. For more information or to order, please contact:
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